but by an act of secretion excited by the impression made upon the mucous membrane. We are not justified, therefore, in assuming, with Longet, that the absorption of solutions of greater density than the blood is always in opposition to the laws of endosmosis.

"The imbibition of the colouring matter of the bile by the coats of the gall-bladder after death, while nothing of the kind takes place during life, is not due to the absence of vital action. During life, the circulation in the mucous membrane of this reservoir would readily remove the few particles of colouring matter which might penetrate from the bile, and of course there is no time for any colouration to take place.

"In treating of the variations and modifications of absorption, we noted an apparent elective power in the mucous membrane of some portions of the alimentary canal. This is illustrated in the failure of the mucous membrane to absorb the woorara and various of the animal poisons, which, as a rule, are only effective when introduced into a wound or injected into the areolar tissue. The separation of various soluble substances by the process known as dialysis may throw some light upon this subject, but as yet we have no facts which offer a satisfactory explanation of this phenomenon. Certain of these phenomena which show an apparent elective power in absorbing membranes are probably due to a cell-action resembling secretion; for all these surfaces are covered with epithelium, which must be penetrated before the fluids can get to the blood-vessels. But even with regard to the selection of materials from the blood to form secretions, very little of a definite character is known.

"Those who believe that absorption is often modified by vital action offer this in explanation of the important influence of the nervous system on this function. Precisely how the nervous system affects absorption, in all instances, it is impossible in the present state of our knowledge to determine; but modifications are frequently effected through the sympathetic system. These nerves, as is well known, are capable of producing important local changes in the circulation, and can even temporarily arrest the capillary circulation in some parts; and it is in this way that many of the variations in absorption may be produced."

With these references to a few of the more important points of its contents, we take leave of Dr. Flint's book. The next two volumes of the series are to be devoted to Secretion and Excretion, Nutrition, Movements, &c., the Nervous System and Generation. If these two volumes should equal the first in excellence of material and style, we feel convinced that Dr. Flint's work, as a whole, will take a high position among modern standard works on physiology. J. A. M.

ART. XIX.—*Traité Expérimental et Clinique de la Régénération des Os et de la Production Artificielle du Tissu Osseux.* Par L. OLLIER, Chirurgien en chef de l'Hôtel-Dieu de Lyon; avec 9 planches gravées sur cuivre et 45 figures intercalées dans le texte. Tome premier, Partie Expérimentale; Tome seconde, Partie Clinique. 2 vols. in-8 maj., pp. xx. 443, 531. Paris: Victor Massonet Fils, 1867.

Experimental and Clinical Treatise on the Regeneration of Bones, and on the Artificial Production of Bony Tissue. By L. OLLIER, Surgeon-in-chief to the Hôtel-Dieu of Lyons; with plates and woodcuts. Two volumes, royal 8vo.

THE name of Ollier is already, doubtless, well known to our readers, as indeed it must be to all who are interested in the progress of surgical pathology, from the very remarkable and admirable papers which he has contributed during the last ten years to the "*Gazette Hebdomadaire de Médecine et de Chirurgie*," the "*Journal de la Physiologie*" (Brown-Séquard's), and other medical periodicals of Paris and Lyons. The subjects which during this time have received his special attention have been the regeneration of bone through the agency of the periosteum, the reconstruction of joints (after articular resections), and what may, perhaps, best be designated as "periosteal osteoplasty," and the production of bony grafts. In the prosecution of his investigations, M. Ollier tells us, he has performed a large number of experiments on the lower animals, and, by his position in the Hôtel-Dieu of Lyons, has, since 1860, been enabled to test and verify the conclusions he had derived from experimentation, by careful clinical observation of a great many cases of bone lesion in the human subject. The fruits of this ten years' cultivation of the wide field laid open before him, M. Ollier has recently communicated to the public in the work contained in the two goodly volumes which are now upon our table.

It is our intention to present our readers with a brief analysis of this result of M. Ollier's labours, and in doing so to examine somewhat critically the applicability of his views to the civil and military practice of surgery.

M. Ollier's work is most appropriately dedicated (as an important contribution to physiological surgery) to MM. Claude Bernard and Velpeau, who may well be considered representative men in the departments of science which they have respectively so brilliantly illustrated.

An interesting preface of twelve pages furnishes some account of the method which our author has pursued in the conduct of his studies, and must serve to convince the reader, that whatever view he may take of the conclusions to which these studies have given rise, the conclusions themselves have been, at all events, carefully and honestly deduced.

The work itself is opened with an introduction, divided into two portions; the first treating "of experimentation upon the bony system, from the point of view of human surgery," and the second giving an "historical sketch of the theories on the regeneration of bones, and of experiments on the osseous system."

The author begins by pointing out the importance and even necessity of experimentation upon the lower animals for the correct study and appreciation of surgery as applied to the bones. The exact ideas which we now possess with regard to the normal nutrition of the skeleton, and the origin of its morbid alterations, date back for not more than a century, and are founded, we are told, on Duhamel's celebrated experiments. Our theories of the formation of callus, and of the reparation of bones in cases of necrosis, were, previous to that period, without any real scientific value, and those points upon which uncertainty still exists, are precisely those which need to be illustrated by further and more accurate experiments than have yet been made. Malgaigne is referred to as the surgeon of modern times who has, perhaps, most thoroughly appreciated the importance of experimental observation; and his classical works on "Fractures and Luxations," and on "Surgical Anatomy and Experimental Surgery," are instanced as exhibiting at almost every page the great advantages which he himself had derived from this method of study. The illustrious names of Hunter and Bichat, with, in later times, Chaussier, Béclard, Dupuytren, Breschet, Cooper, Travers, Heine, Amussat, and

Jobert, may be enumerated in the same category, as surgeons who have recognized the necessary dependence of practical surgery upon the carefully conducted study of experimental physiology.

At the end of the last century and at the beginning of this, when the modern practice of resection first came into notice through the labours of White, Moreau, and others, the question of the reproduction of bone was argued, but without any practical result, for affirmative were simply balanced against negative cases, without any attempt to explain why in certain instances a true bony reproduction took place, which in others was entirely deficient. The fact was, that those cases where the parts removed were regenerated, were cases of necrosis, where the periosteum had been spontaneously separated by the diseased action; while in healthy bones it was almost if not quite impossible, by the operative procedures then employed in resections, not to destroy the periosteum, and thereby totally prevent any bony reproduction whatever.

While there are still numerous points in the process of development of bone which require further elucidation, the microscope has served to throw light upon other points which were long eagerly, though blindly debated. "In following the modifications of the cells of the periosteum, it has been seen that the transformation of this membrane into bone was a reality. Accordingly, upon this point there is no diversity between Virchow and Duhamel, but simple variations of language, explicable by the difference of times."

The questions most urgently calling for investigation at present, in view of the existing state of surgery, are that of the regeneration of bones after resections or total excisions, and that of periosteal and osseous osteoplasty.

Besides these, the general theory of the growth of bones healthy and diseased, resected and reproduced, and that of the healing of these organs after fractures or after lesions which affect the various elements of their tissue, demand special development.

These matters can only be properly studied by careful and painstaking physiological and pathological experimentation. Our author quite appreciates the absolute necessity of *accurate* and *oft-repeated* experiments: "The history of Experimental Physiology is encumbered by unproductiveness, and nothing has so much retarded the progress of this science at certain periods, as defective experiments, announced with *éclat* and sustained by a great name." Not only must allowance be made, in experiments upon normal nutrition, for the new and disturbing element introduced by the irritation of the experimental procedure itself, but account must also be made of the effect of a change in one tissue upon the tissues adjoining—something like what the older writers would have called a "sympathy by contiguity." Thus, there is demonstrable a sort of action by presence on the part of bone, and especially of its periosteum, which gives rise to a special tendency to ossification in all the connective tissues in the neighbourhood.

M. Ollier's experiments have been made upon dogs, cats, rabbits, sheep, pigeons, chickens, etc. Bone is more easily reproduced by the periosteum in the lower animals than in man, but it does not follow that it should be more easily reproduced in those which are lowest in the scale of creation, than in those whose structure more nearly approaches that of the human being. Thus "transplantations of periosteum succeed much better in the dog and cat than in the sheep and calf, and yet the two latter animals are considered further removed from man."

Our author well states the limits of the applicability of experimental physiology to surgery :—

> "It must not be thought that an operation is sure to succeed in man merely from the fact that it is perfectly tolerated by certain animals. Experimental physiology does indeed furnish the surgeon with very legitimate motives of action, but clinical observation alone must exercise the final judgment. It is above all in another point of view that the utility of experiments should be considered; their principal advantage is to separate, to decompose complex facts which can only be unravelled by isolating their elements. We seek simple facts, and we exercise our ingenuity in reproducing them. We then decompose complex facts in order to arrive at their interpretation. By proceeding thus, we find laws which are applicable to all animals that have the same conformation, and which consequently are applicable to man."

The experiments of Duhamel, Troja, Heine, Flourens, and others, brilliant and satisfactory as they were, did not succeed in establishing the doctrine of the regeneration of bone from periosteum, as an acknowledged truth, with either physiologists or surgeons. It was not until the idea occurred to our author of experimenting by the *transplantation* of periosteum, that the demonstration became irresistible, and the conclusion not to be gainsaid.

These preliminary considerations appropriately lead the way to the second portion of M. Ollier's introduction, which gives a brief historical sketch of the theories and observations of days preceding his own.

We shall not attempt to follow our author through this part of his subject, though it is full of interest, and in its manner of treatment shows wide research and careful and conscientious analysis. We may simply observe that M. Ollier divides the history of his subject into two periods, that of pure observation, from the time of Hippocrates and the earliest medical writers to the days of Havers (the describer of the so-called Haversian canals), and the second or experimental period, beginning with Duhamel (1739-1757), and coming down to the present time. That bone can be reproduced and that the periosteum is capable of reproducing it, have been repeatedly demonstrated by both experiment and clinical observation, and yet the practice of surgery, as regards resections, has been unmodified by these demonstrations until very recently. In fact, as remarked by our author, there are still, as at the beginning of the century, two classes of adversaries to be contended with; those who admit that bone may be regenerated, but who think the periosteum unnecessary for the purpose; and those who deny the possibility of osseous reproduction, even though the periosteum should have been most carefully preserved.

From motives of convenience, M. Ollier has divided his work into two portions, the first experimental, the second practical or clinical. The first part (occupying with the introduction, already considered, the first volume) contains fourteen chapters, and of these we shall now endeavour to furnish our readers with a short but sufficient analysis.

Every bone is formed of three essential constituents, viz., periosteum, marrow, and bony structure proper; to these may be added a fourth, cartilage, which, however, in the case of a great many bones, acts a part which is only temporary. These several substances are in variable proportion, according to the kind of bone and its period of development. Physiologically and pathologically they are intimately united, though each has distinct functions, whether in the normal development of bone or in the various morbid processes to which it may be subjected. To ascertain, therefore, their relative share in the complex phenomena of normal and accidental ossification, it is necessary to make each the subject of special study in its individual power of action.

To demonstrate the possibility of the periosteum alone giving rise to a new formation of bone, M. Ollier describes three series of experiments which he has performed, by transplanting portions of this membrane to a greater or less distance from their natural position. In the first series, he dissected up a flap of periosteum, having first separated it from its muscular connections, and spread it out in a kind of nest previously prepared in the surrounding soft tissues.

One extremity of the periosteal flap was permitted to retain its natural attachments, while the other was secured in its new position by a single suture. The wound then being carefully closed, immediate union was generally obtained, and the animal being sacrificed at periods varying from six weeks to three months, well-marked new formations of true bone were found to have been developed from the transplanted membrane, the size and shape of the new portions corresponding with the size of the periosteal flaps, and the positions in which they had been placed. These experiments were performed on rabbits, cats, and dogs, success in the latter being more difficult to obtain, on account of the proneness to suppuration generally observed in wounds of that animal. The bone generally employed was, from motives of convenience, the tibia; though a perfectly successful result was secured in one instance from the periosteum of the skull in a cat.

A second series of experiments was then instituted, in which, when the process of ossification in the transplanted flap had already begun, its remaining attachment to the main body of periosteum was severed. In these experiments it was found that the process of bone formation went on just as well after as before these connections had been destroyed; and it was thus shown "that the production of bone goes on and is completed by the periosteum's own power of action, when the flap has already contracted adhesions with the tissue in the midst of which it is placed."

The third series of experiments carries the demonstration still further, and shows that even the temporary continuity with the main body of periosteum is unnecessary. In these experiments the periosteal flap, having been bared and dissected, as in the previous series, was absolutely removed from all its attachments and transplanted or grafted into a widely distant part of the animal's body. By this plan true and distinct bones, with true periosteal coverings, and containing marrow cavities and marrow, were developed wherever the graft could be inserted. Thus a strip of periosteum from the tibia of a rabbit produced a bone beneath the scalp; the new formation, at certain points, being as thick as the diaphysis of the ulna had been at the time of the experiment.

As was before observed, these experiments are not equally successful with all animals. They almost always fail with those of the ruminant class on account of suppuration of the wound, while in the dog, cat, and rabbit, primary union and success can generally be obtained.

> "It is only by direct experimentation, in every case, that we can ascertain the greater or less aptitude of any particular animal for the periosteal graft. Accordingly we do not know as yet whether the transplantation of periosteum to a distance would produce osseous tissue in man, but everything leads us to believe that it would, provided that union by the first intention could be obtained, and that a young and healthy subject should be chosen for the experiment."

In old animals, the periosteum, though it may contract adhesions in its new position, will remain fibrous without any development of bone. Other causes which may hinder or prevent the success of the experiment are carelessness in the operative procedure, accidents to the wound after the operation, want of care in removing foreign bodies from the wound, or a bad state of health in the subject selected for experiment. While advanced age will interfere with the production of bone from periosteal grafts, too great youth, on the other hand, may produce likewise a deleterious effect, the transplanted portion itself becoming absorbed, as was found in three experiments made on dogs within ten or fifteen days after birth.

Again there is a difference as regards the bone from which the periosteal graft is derived. As a rule that obtained from the long, answers better than that taken from the flat bones, and in the former the portion nearest the joints does better than that from the centre of the shaft; this is explained by the fact that the periosteum in proximity to the articulations is thicker than at any other portion of the bone.

A curious experiment was performed by M. Ollier, with a view of determining the true function of the *dura mater;* two strips of this membrane, derived from the vault and the base respectively of the cerebral mass of a rabbit six weeks old, were inserted, one into either groin of another rabbit aged two months. Forty-one days later the strip from the convexity of the brain had produced a uniform osseous mass of the dimensions of a grain of wheat, while that from the base, although likewise ossified, was so in little isolated granules, which taken together scarcely equalled a half of the bony mass produced from the first strip. The difference is probably explicable by the very close adherence of the dura mater to the base of the skull, which renders its separation in that locality more difficult, and increases the probability of portions being left behind which are of the external layer, and that which is best adapted to the regeneration of bone.

In adult rabbits, no new development of bone was obtained, but a remarkable circumstance is that in all cases more bone was produced by the transplantation of dura mater than of pericranium.

Having demonstrated that the periosteum has in itself the property of producing true bony tissue, our author next proceeds to inquire whether, in the discharge of this function, the periosteum acts as a whole, or whether the osteogenetic power is an attribute of any particular portion of its structure. The following brief account of the microscopic appearances of the periosteum, we condense from M. Ollier's description:—

"There is first (going from without inwards) a thin layer of loose connective tissue, containing fat cells; but this layer does not, strictly speaking, belong to the periosteum; it results from the imperfect separation of the surrounding areolar tissue. This layer having been removed, we find a tissue of fibrous appearance, closely knit, and formed of very small corpuscles of connective tissue, united by an intercellular substance in the form of fine undulating fibres. This can be divided by needles into very close bundles, like dense fibrous tissue; it contains numerous elastic fibres. Towards the internal surface of the periosteum the cells become larger, the intercellular substance still retaining its fibrous appearance, and the elastic fibres become more and more numerous. If now the preparation be taken up by its internal or deep surface, elements of entirely different aspect are presented; these are oval or fusiform cells in the midst of a more or less distinct intercellular substance, which is granular or fibroid. Most of these cells have but one nucleus, but a certain number will be found in process of proliferation. Some, even, those which are nearest the bone (seen especially in very young subjects), have altogether the appearance of the polynucleated cells of the marrow."

This structure is continuous with, and passes gradually into that previously described. This inner layer of the periosteum has been designated by various names, according to the different views of pathologists; thus Kölliker calls it the "blastema of ossification;" Virchow names it the "periosteal layer of proliferation;" while according to Ranvier (*Thèse Inaugurale*, Paris, 1865), upon whose views our author is disposed to look with much favour, it is formed of true marrow cells, which serve directly for the growth of the bone in thickness.

By the same process of physiological analysis which M. Ollier adopted in his previous experiments, he now proceeds to ascertain which portion of the periosteum is that which is concerned in the formation of bone; and he clearly demonstrates, (1) that the periosteum, deprived of its inner layer, is no longer possessed of osteogenetic powers, and (2) that portions, no matter how minute, of this inner layer, when transplanted, can and do produce particles of new bone, and that consequently this layer is entitled to the name which he proposes for it, of the "osteogenetic layer of the periosteum."

It is, however, to be observed that the external layer alone, after a long time (six months in one case), does regain partially the properties of the periosteum before being deprived of its osteogenetic portion, and a real, though very imperfect formation of new bone, may thus be obtained. It is also to be observed, that in detaching the periosteum from the bone, a part of the osteogenetic layer is left adhering to the latter; this performs an important part in the development of a new periosteum, as is not unfrequently seen in scalp wounds and other injuries of like nature.

Having established that the periosteum has the property, when transplanted, of giving rise to the development of new bone, our author next proceeds to demonstrate the complementary proposition that bone cannot be produced by the transplantation of any other analogous fibrous tissue. Experiments were made with tendons, aponeuroses, and fibrous capsules, and with the single exception of the *dura mater* (before referred to), the osteogenetic power was found to be limited to the periosteal, among all the fibrous tissues of the body. In one experiment, made with the tendo-Achillis of a rabbit, an apparent production of bone was observed; but examination with the microscope showed not ossification, but calcification merely; a not very unfrequent result of traumatic irritation of tendinous structure.

The osteogenetic property of the periosteum may then be considered as an established fact; the manner in which that property is exercised is, however, still an open question. The osteoplast or osseous cavity, it is generally conceded, is developed around a previously existing element. The theory of Ranvier, which our author is disposed to adopt, is as follows: there is, first, a dissolution and disappearance of the primitive intercellular substance of the periosteum, the cells themselves being as a consequence set free; these cells are subsequently arranged in concentric layers, and a new intercellular material is developed which finally becomes the true bony substance.

Virchow, as is well known, believes in a direct transformation of the connective tissue corpuscle, with a simultaneous invasion of the intercellular substance; this view, however, as pointed out by Robin (*Journal de l'Anatomie et de la Physiologie*, Sept. 1864), does not account for the arrangement of the osteoplast in concentric layers. The distinguished editor of the *Journal de l'Anatomie*, himself, explains the development of bone by supposing the existence of a temporary layer of cartilage beneath the periosteum; this he terms "ossification by encroachment," the cartilage being invaded by a calcareous deposit at the moment of its formation. M. Ollier believes the production of cartilage from a transplantation of periosteum to be accidental, and due to an excess of activity in the transplanted portion; but, under any circumstances, the question has lost its importance since Virchow has shown that cartilage and connective tissue are interchangeable equivalents, which can replace each other, and which often proceed from the same source.

There is a limit to the growth of *hetero-topic* bones, or those developed from periosteal grafts. In the first place, as they have no "cartilage of conjunction,"[1] they do not increase in length, and secondly, although the contrary might be supposed *à priori*, they do not grow in thickness commensurately with normal bones in the same subject; the process of ossification ceases, as soon as all the ossifiable elements have been exhausted.

The structure of hetero-topic bone is fundamentally the same as that of normal bone; but it is to be noted that it resembles *very young* bone, more than that which is found in the adult. A very beautiful plate is given, showing the microscopic appearances of the new-formed osseous tissue.

With regard to the osteogenetic layer of the periosteum, at the commencement of his investigations, M. Ollier, influenced by the prevailing histological doctrines of the day, denominated it a subperiosteal blastema; he has since recognized that it is no exudation or amorphous new material, but that it has, in every stage of its development, the same fundamental structure as the rest of the periosteum, of which it is, indeed, but the active and bone-producing part.

M. Ollier's second chapter treats of the *marrow* and of its effects in the formation and nutrition of bones. The majority of the older anatomists supposed the marrow to be inclosed within a delicate but demonstrable membrane, to which they gave the name of medullary membrane, or internal periosteum. Even during the last century, however, the existence of such a membrane was denied by the illustrious Ruysch, and its non-existence has more recently been clearly proved by the researches of Gosselin, Regnault, and others. The external layer of the marrow is, indeed, somewhat different from those more deeply seated; it contains fewer fat-cells, and more of the polynucleated cells to which Robin has given the name of *myéloplaxes.* It is, in fact, of more recent formation than the deeper portions of the marrow, and we are thus led to a view of the true function of this substance in its normal condition. As the bone is formed directly from the periosteum, the marrow is in turn formed from the innermost layers of its surrounding bone, whether by direct proliferation of the osteoplasts, disembarrassed from their calcareous envelope by liquefaction of the fundamental substance (Virchow), or otherwise, cannot at present be positively determined. The fact is, however, established that the medullary cavity grows at the expense of the inner layers of bone, not by a distension of its osseous envelope, but by a direct process of transformation whereby the inner layers of bone disappear as others are added exteriorly by development from the periosteum. The limits of our space will not permit us to go into the experimental details by which these positions are established; suffice it to say, that all of M. Ollier's investigations have been conducted with the same care and scrupulous attention to accuracy that characterized those to which we had occasion to refer, in considering his first chapter.

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[1] By this term "cartilage of conjunction," M. Ollier designates the temporary cartilage which connects the diaphysis of a bone with its epiphyses.

Though the property of marrow in its normal condition, is, as we have seen, rather antagonistic than analogous to that of the periosteum, yet under certain circumstances, it has itself the power of ossification independently of its surroundings. Marrow, when transplanted, never produces bone; this has been established by M. Ollier by at least fifty distinct experiments. When isolated, however, *in situ*, by means of a metallic tube thrust into the medullary canal, the case is different; under these circumstances, M. Ollier has obtained from the marrow itself a well marked new osseous formation. The marrow is thus seen to differ from the periosteum, in that while the latter normally tends to bone production, the former only does so when its cells are recalled to activity by a certain amount of irritation; nor must this irritation be too great, for if excessive the marrow will break down into pus; there being, in fact, as remarked by Virchow, no tissue more disposed to purulent transformation.

The marrow, unlike the periosteum, is exceedingly sensitive to pain; its sensibility increases in proportion to the nearness of the source of irritation to the nutritious foramen of its containing bone. The marrow is extremely vascular, but, contrary to what might be supposed, its nutritious vessels may be obliterated, without compromising the vitality of the bone. The absorbing powers of the marrow are very great. The injection of ten drops of a concentrated solution of cyanide of potassium has produced death in rabbits in from ten to twenty seconds, the rapidity being proportionate to the proximity of the place of injection to the trunk. The same amount of liquid injected into the liver, the lung, or the peritoneal cavity, did not produce fatal results.

Chapter Third treats of bone tissue proper, studied with regard to its individual activity and its relations with the periosteum and with the marrow. The intimate structure of bone is well described, and the processes of ossification and calcification duly considered, and the differences between them pointed out. The effects on bone of the removal of its periosteum are then considered; as already intimated in chapter first, under favourable circumstances, necrosis will not ensue, but a reproduction of true periosteum will take place. This is accounted for by the fact that a portion of the osteogenetic layer still adheres to the bone, and it is by its proliferation that the new periosteum is formed. That this new material is true periosteum is proved by the experiment of transplantation, by which new bone can be obtained just as from the original periosteum, though in much less quantity. This process cannot, however, be repeated indefinitely, and M. Ollier has never succeeded in procuring bone from the transplantation of periosteum of the third generation. Hence the author's conclusion that "the reproduction of periosteum, indefinite as far as it constitutes a cicatricial membrane, is, on the contrary, very limited as regards its property as an osteogenetic membrane. However real may be the activity of the superficial layer of the bone, this activity is diminished, exhausted, or changed in direction after a first denudation. The new cells are no longer fitted for ossification after they are removed from the bone. Nevertheless, in place, if the irritation continue, they may give rise to osteophytic productions, which may even rise beyond the level of the denuded surface."

A single removal of periosteum does not diminish the thickness of bone, which in young subjects may even become hypertrophied at the point of operation. Successive denudations, however, produce a depression which continues permanently. One curious fact is that bones bared of periosteum increase *in length;* a circumstance only to be explained by the supposition of a formative irritation propagated throughout the entire extent of the bone to the cartilages of conjunction.

If, after removing the periosteum, the bone be thoroughly scraped, so as to destroy any remnant of the osteogenetic layer, the periosteum will in time be reproduced, though more slowly than when that layer is allowed to remain; but the new periosteum will not in this case have the property of reproducing bone when transplanted.

Similarly, when superficial necrosis follows periosteal denudation, a cicatricial membrane will in time be reproduced; but as in the preceding case it will have no true osteogenetic power. The process by which this cicatricial membrane is developed is manifestly by proliferation of the superficial layers of the true bone tissue, and of the medullary matter contained in its canaliculi.

Destruction and removal of the marrow is not necessarily followed by necrosis of the surrounding bone. Under favorable circumstances, a new marrow is very rapidly formed, which, if the irritation continue, may further undergo the process of ossification.

Even the simultaneous removal of both periosteum and marrow, will not always give rise to necrosis; in one experiment of M. Ollier's on a healthy dog three months old, a new periosteum was formed at the end of five weeks, the medullary cavity was filled with a spongy bone tissue rather larger than the portion of marrow removed, and the whole bone itself was considerably hypertrophied.

A section on the chemical composition of bone in its various physiological states concludes the chapter.

Chapter Fourth treats of cartilage and of its part in the process of ossification. A good summary of the respective views of Robin, Kölliker, Virchow, and Müller, is given, and M. Ollier expresses his preference for the theory of the latter, as modified by Ranvier. "The essential characteristic of cartilaginous tissue is the formation of a cavity around a cell, known as the primordial cell. These cavities are disposed in a variable manner in the midst of a fundamental substance, which is hard, resisting, homogeneous, or fibroid." According to the theory which our author adopts, it is the true cartilage cell, or that contained within the cavity above referred to, which becomes the osteoplast, that cavity having been in the first place transformed into medullary tissue. The fundamental substance undergoes calcification, but no true ossification, and finally disappears by liquefaction and absorption.

Cartilage has an interstitial growth, in addition to that which depends on the perichondrium; this membrane shows its resemblance to periosteum by being transformed into the latter, in the case of the temporary cartilages.

M. Ollier has not succeeded in obtaining cartilage by the transplantation of perichondrium; from that derived from the epiphyseal cartilages he has found small bony nodules developed, while that taken from the permanent cartilages has remained fibrous.

Cartilage deprived of its perichondrium does not necessarily perish; when, however, transplanted in this condition, it is incapable of producing a graft.

Cartilage transplanted with its perichondrium may indeed be successfully grafted, and under favourable circumstances may undergo ossification. But the proliferation of its cells is not like that which takes place in the normal development of bone. While the *periosteal* graft produces a new bone of considerable dimensions, that originating from transplanted cartilage is never larger, and generally smaller, than the cartilage itself from which it is developed. An exception is noted in the case of *rats*, in which animals, according to Bert, transplantation gives to cartilage greater activity than if it were allowed to remain in its normal position.

Chapter Fifth treats of traumatic irritation of the different elements of bone, and of other substances of connective tissue formation. The effects of traumatic irritation upon these various parts of the body must be studied, in order to understand the accidental development of anatomical elements in tissues to which they do not normally belong. The general result of any traumatic irritation is the same in all the forms of connective tissue. As pointed out by Virchow (*Cellular Pathology*, Lect. XIV., Chance's edition, pp. 306 *et seq.*), the first effect is the enlargement of the cells, the proliferation of their nuclei and nucleoli, and the formation of new cells; the intercellular substance is for the time being unaffected. Soon, however, there is a perceptible tumefaction and change of colour in the intercellular substance, corresponding with its diminished transparency and the development of new vessels in its interior.

The rapidity with which these changes occur varies very much according to the tissue affected. In the deep (osteogenetic) layer of the periosteum, and in the marrow, where the intercellular substance is loose and unresisting, these modifications take place more quickly than in the fibrous and cartilaginous tissues where the intercellular substance is more dense. The process is still slower in the osseous elements, and almost totally inappreciable in the completely formed adult bone.

If the irritation be but slight, a gradual return to the normal condition may occur; or the process of change may be arrested, without, however, any retrogression, and there will then remain chronic induration and persistent increase of volume in the part affected. It is under these circumstances that the intercellular substance becomes sclerotized, and calcification or even true ossification may take place in tissues which normally do not tend to the production of bone. If the irritation be excessive, and especially if the tissue affected be rich in cells, a purulent transformation may occur, and *suppuration* will ensue; or before this stage is reached, a smaller or larger portion of the tissue concerned may die, and *sloughing* or *necrosis* will precede the formation of pus. This is particularly apt to happen in the case of bone, which is predisposed to a loss of vitality from its capillaries being inclosed in narrow and inextensible channels.

Under other circumstances, a prolonged chronic irritation may bring about secondarily a retrograde metamorphosis, giving rise to granular or fatty degeneration. In these cases there is a gradual absorption or disappearance of the tissue affected, the intercellular substance seeming to melt away, while the cells become successively obliterated.

Of course it is not M. Ollier's intention in his book, nor is it ours in this review, to furnish a complete account of the pathology and processes of inflammation; but the preceding very brief sketch has seemed necessary as a preliminary to the proper understanding of the remarks that are to follow upon osteitis and its terminations.

Direct irritation of the periosteum is very apt to be followed by suppuration; but irritation transmitted either from the bone or from the surrounding soft tissues, excites the osteogenetic powers of the periosteum to fresh activity and a new production of bone is the result. In old bones this activity is more readily excited than in those of young persons. It is upon these facts, we may observe, that greatly depend the success of any measures for the cure of ununited fractures. The periosteum must be handled very delicately, or the operation itself, by exciting suppuration, will forbid the hope of success. We can understand too, from the above considerations, the occasional success of blisters in cases of bony non-union. The irritation being transmitted indirectly to the periosteum excites its osteogenetic property, without producing suppuration, and a cure is thus sometimes brought about. One valuable hint given by our author in this place, is that before operating on the periosteum of an old subject, it should, in the first place, be rejuvenated, as it were, by repeated slight or indirect irritations. Its vitality may thus be preserved, when if dissected from the bone without such previous preparation, it would have been very apt to become gangrenous, or at best to remain fibrous without any attempt at bone formation.

Irritation of the marrow may, as before observed, cause ossification of that structure, though more apt to produce suppuration. Irritation of the marrow will however be frequently transmitted to the periosteum and give rise there to a new bone formation, even more voluminous than would be produced by irritation of the periosteum itself. A very curious result is occasionally observed; the irritation of the marrow may cause suppuration of that substance, the bone be completely transformed into a new medullary tissue, while a voluminous formation of fresh bone is developed beneath the periosteum, the bulk of the whole being double what it was before the institution of the experiment. Similar phenomena are sometimes met with in cases of osteitis in the human being, and especially in children. M. Ollier has seen almost complete medullization of the phalanges, without the least necrosis, brought about in the short space of twenty days, by an attack of acute osteitis (*acute caries* of Ribes). The same thing he has observed in the case of the tibia of a youth of fifteen years; in this instance, however, slight necrosis had occurred at some points, and the disease had lasted two months.

Traumatic irritation of the bone itself may produce an immediate increase in the number of osteoplasts, or, on the other hand, may cause a hyperplasia of the marrow cells in the interior of the Haversian canals. In the latter case the process may continue by an absorption of the bony substance, with rarefaction and subsequent suppuration of the parts previously medullized. Or if the irritation cease before this effect is produced, the process of decalcification may be arrested and the formation of osteoplasts be resumed. This may even go so far as to result in a veritable eburnation, in this case the cure of the inflammation, or it may, as before observed, be the primary effect of a chronic, slow, and long-continued irritation.

Irritation of one of the elements of bone is always transmitted more or less to the others, and is always more or less diffused beyond the point originally affected. As a result, the same bone may present all degrees and varieties of inflammation. In one part there may be undue medullization—in another, eburnation; here, suppuration and necrosis—there, an exostosis, or ossification of the marrow. The irritation (especially in the young) may be transmitted to the cartilages of conjunction, and by exciting fresh energy in the proliferation of their ossifiable elements, the length of the bone may be considerably increased. Thus osteitis affecting the diaphysis of a long bone may make the limb affected longer than the healthy limb of the other side of the body, a fact not unfrequently observed in the human subject. Osseous hypertrophy often follows upon irritation of the surrounding soft tissues; this is constantly seen in cases of old ulceration of the leg. Pressure may produce hypertrophy, as in the exostoses accompanying corns; or it may produce exactly the opposite effect, as in the formation of new joints after unreduced luxations.

"The law of accidental ossification is not yet well understood." The long continued use of a tube after the operation of tracheotomy has produced ossification of the tracheal rings; wounds and especially fractures of the costal cartilages are constantly followed by peripheral ossification of the perichondrium; on the other hand, the nasal and auricular cartilages are almost never the seat of bone formation. A curious *action by presence* on the part of the periosteum and other elements of bone is certain, but inexplicable; the same tissues which around an intermuscular abscess become indurated merely, in the neighbourhood of a suppurating periostitis, become positively ossified.

Inflammation does not affect the bone cells proper, except secondarily; its first effects are produced upon the marrow cells, the osteogenetic layer of the periosteum, and the contents of the Haversian canals. The only positive changes that can be recognized in the bone cells themselves, are those which are necro-biotic, the fatty and granular degenerations: these, however, seem sometimes to exist as a primary diathesis, and in such cases a frank traumatic irritation may sometimes serve to bring about a cure.

Necrosis is universally the result of *osteitis;* the capillaries of the Haversian canals become, as it were, strangulated against the bony walls which surround them, and arrested circulation, and death of the part deprived of blood is the consequence. Some interesting experiments are narrated, touching upon the artificial production of necrosis, which want of space compels us to pass over. Our author defines *sequestrum* as a portion of bone separated, but not necessarily entirely dead: in fact, as he remarks, the majority of sequestra extracted by surgeons are vascular in at least a portion of their extent. It is by the absorption or medullization, which goes on in this still vascular and living portion, that sequestra are finally spontaneously separated from the bones to which they have been attached. Bone that is actually dead is not changed by contact with the living tissues; our author in this point confirms the views of Mr. Gulliver, published in the *Medico-Chirurgical Transactions* for 1838. With regard to the term *insensible exfoliation*, our author very properly denies its applicability to the *absorption* of inflamed bone, and restricts its use to those cases where there is an actual throwing off of bony particles, minute though those particles may be. The recent experiments of Savory and Gmelin, on the absorption of sequestra, are referred to in a note; the observations of the English writer showing that *pressure* was the cause of the absorption, when met with.

Chapter Sixth gives us a very excellent account of the process of repair in bone wounds, and of the formation of callus. The reader who has followed M. Ollier through the preceding portions of the volume, will now be able to clearly understand this, which, as generally taught, is one of the most obscure and unsatisfactory subjects in the whole range of surgical pathology. We would gladly transcribe for our readers a considerable part of this most valuable chapter, but the space already consumed in our analysis of what has gone before, and which was absolutely essential to a comprehension of the rest, warns us to forego that pleasure, and to content ourselves with very brief extracts.

The simplest form of fracture, and that in which the process of repair should, therefore, be first studied, is where the periosteum is not injured; in fact a subperiosteal fracture. Provided the bone be kept at rest, the only external phenomenon during the cure, is a slight tumefaction of the periosteum. This swelling is due to a hyperplasia of the deep or osteogenetic layer. At the same time the marrow becomes indurated, and generally undergoes ossification at the seat of fracture. The bone tissue itself remains ununited for a much longer time; it is only by a secondary process, as seen in chapters third and fifth, that it becomes fused with the new formations without and within, and that finally the solution of continuity is definitely repaired. Thus we see that the whole process of healing after fractures, the formation of the "provisional callus," so-called, and the various phenomena which all students find so complicated and so mysterious, are resolved into a perfectly simple and natural course of events, which is in fact nothing but an exaggeration of the process which is constantly going on in the normal growth and maintenance of bone tissue. This exaggeration is due simply and solely to the traumatic irritation. There is no mysterious organization of a previously exuded juice, no development of blastema or of exudation corpuscles, no transformation of blood clots or of supposititious lymph. There is no new process brought into action; nothing but a *traumatic excitation of the ordinary bone producing functions of the periosteum and other elements of bone.*

In fractures with great displacement, shortening, and overlapping of fragments, the periosteum is still almost never entirely broken across; the broken extremities of bone penetrate its sheath above and below, and the periosteum still serves to unite them by a kind of bridge passing obliquely between them. This periosteal bridge, in the process of healing, forms the bond of bony union. The osseous mass which is hence developed often exceeds in thickness the shaft of the original bone. A narrow cavity is gradually formed in its interior, which may finally communicate with those of the upper and lower fragments respectively; and the projecting extremities of these becoming absorbed and rounded off, more or less quickly, according to the age of the bone, the continuity and form of the osseous cylinder may in time be measurably restored.

In compound fractures the process of repair is the same; but it does not begin until the traumatic inflammation has subsided, and until suppuration has been fairly established.

The presence of *cartilage* in callus, as in the development of heterotopic bones is only temporary and due to excessive irritation.

In epiphyseal separations, the line of rupture is not through the cartilage of conjunction itself, but through the spongy layer at one or the other side. These injuries are repaired like wounds of bone rather than like those of cartilage. Even if immediately reduced, the growth of the bone in length is hindered as a sequel of the accident. On the other hand the thickness of the part will generally be permanently augmented.

The causes of *non-union* after fractures are rapidly discussed, and the labours, in this field, of our eminent townsman, Dr. Geo. W. Norris, briefly adverted to. With regard to the administration of phosphates in cases of this nature, M. Ollier states that he has never been able to satisfy himself that they produced any good result; though he continues their use, from a conviction that at any rate they can do no harm. Our author has experimentally confirmed the views of Bernard and of Virchow, in opposition to those of Schiff, to the effect that section of the nerves of a limb produces no direct injurious effect upon the process of callus formation.

Fractures and wounds of the cartilages that have an investment of perichondrium, are united by an osseous or fibrous callus developed from that membrane. The edges of the cartilage themselves do not unite, though remaining in close juxtaposition. Wounds of the articular cartilages in very young subjects are united by a cicatricial tissue, which, however, assumes but imperfectly the characteristics of true cartilage. Wounds of the cartilages of conjunction unite by a cicatrix, which remains permanently fibrous.

Chapters Seventh and Eighth are devoted to a consideration of the regeneration of bones after resection or total excision; the former discussing the matter with regard to bones in general, and the latter taking up the question in the cases of the several classes of bones in detail. These chapters are full of interest, and replete with practical instruction. The principles and mechanism of bone formation, as described by our author, have, however, been so fully set forth in the preceding pages, that it will not be necessary for us to linger over the present portion of the volume. Suffice it to say, that M. Ollier has obtained complete reproductions of portions and even of entire bones in rabbits, cats, and pigeons, from the periosteum alone. We consider that he has well established the fundamental proposition, which he announces in the following terms: "The periosteum alone gives rise to veritable regenerations. Isolated from all other tissues of bone, it can, by itself, under certain circumstances, reproduce an entire bone, or a considerable bony portion, representing the form and fulfilling the functions of the organ removed." The remaining elements of bone tissue (marrow, cartilage, etc.) do indeed possess the bone producing power in a more or less limited degree, and under certain exceptional circumstances; but neither of them nor all of them together, *without the periosteum*, can be justly said, ever or in any way to exercise the property of causing a true *regeneration* of bone previously removed. "They undergo ossification in the neighbourhood of the periosteum, and aid it in its functions; but they cannot take its place."

While the process of regeneration in all bones is the same, the facility with which they can be regenerated varies greatly according to the nature of the bone concerned. In general terms it may be stated that the ease with which a bone can be reproduced is proportional to its thickness, and in the same bone reproduction will be most complete as regards those parts that are thickest. This depends upon the fact previously noted, that it is in those parts that the osteogenetic layer of the periosteum is best developed.

In the long bones, the central part of the diaphysis is the slowest of regeneration, and ossification not unfrequently fails at this portion, even when the epiphyseal extremities have been completely reproduced. The actual regeneration of the epiphyses has been doubted, it being supposed that the dilated extremities of the diaphysis took their place; but that they are really reproduced, is proved by the formation of new cartilages of conjunction, separating the epiphyses from the diaphysis as in the natural bone. The only parts not reproduced are those covered with cartilage of incrustation. There is no periosteum in this locality, and of course no osseous regeneration.

M.Ollier has obtained in the dog partial regeneration of the humerus, after subperiosteal excision of the whole of that bone. The new formation was of the same general shape, though smaller, than the original bone, and it is to be specially noted that all the muscles of the part retained their relative points of origin and insertion, just as in the limb before the operation.

> "In spite of the shortening of the member, a like result would be of inestimable value in the human subject, should it be determined to remove the whole humerus. The use of the hand would be in part preserved, and all the movements would remain possible to a certain degree. *In the lower extremity*" (the Italics are ours) "*the same result would be altogether insufficient, and would have totally different consequences in view of the functions of that part.* It must, on the other hand, be remembered that if the entire periosteum should be removed in a similar case, there would not be obtained even the shadow of a regeneration."

Flat bones may be divided into three classes; (1) such as are surrounded with muscular tissue, as the scapula, the ilium, and the sternum; (2) such as have their periosteum continuous with a mucous surface, as the bones of the palate; and (3) those whose periosteum is lined with a serous membrane, as the bones of the skull, where, as has been seen, the dura mater is a bone-producing agent. Our author has obtained complete reproduction of the scapula in the dog and in the cat, and of the palatine vault in the dog; in one case from the palatine periosteum alone, that on the nasal surface having been destroyed. He has also obtained complete bony reproduction after trephining the skull of a sheep; though the regeneration of the cranial bones is as a rule unsatisfactory in the extreme. M. Ollier has obtained complete reproduction of the cuboid bone in a rabbit, and partial reproduction of the calcaneum in the same animal. He has not himself experimented upon the spinal column, but has in his possession a specimen given to him by Prof. Brown-Séquard of the reproduction of the posterior part of four vertebræ resected from the spine of a guinea-pig. The vertebral arches are fused together, but the spinal canal has been completely formed anew.

Chapter Ninth treats of the reconstitution of new joints between the reproduced articular extremities of bones. The difference in result, according as the periosteal and other fibrous constituents of the joint, with the muscular attachments, are preserved or sacrificed, is pointed out first as to joints in general, and secondly in the case of the individual joints, with the variations due to their nature as they belong to the ginglymoid, ball-and-socket, or mixed forms of articulation.

Not only is the preservation of the periosteum essential for the perfect reproduction of the articular extremity of a bone, but without it the *shape* of whatever new structure might be formed would be unsuited for the fulfilment of its functions. Moreover, besides serving as a mould to determine the form of the new material, the periosteum (together with the other fibrous tissues of the joint) acts an important part as a kind of internal splint to keep the articulation at rest during the period of the reproductive process.

In subperiosteal resections of joints as of the long bones, the attachments of the muscles are preserved, and in the new formation their points of origin and insertion will be relatively the same as in the natural condition of the part; whereas if the periosteum be sacrificed they will form new adhesions in irregular and vicious positions, and as a consequence the usefulness of the limb will be greatly hindered if not entirely abolished.

M. Ollier has obtained, by subperiosteal resection, almost complete reproduction of the elbow, knee, and shoulder-joints in the dog, and, which is still more important, an equally good result in the case of the latter articulation, in the human subject.

In Chapter Tenth are considered the mode of development and structure of reproduced bones and of new articulations. The process of formation of new bones in place of those removed by periosteal excision, does not vary from that heretofore studied in the production of heterotopic osseous productions, and in the repair of fractures and other injuries of bone tissue. It is, however, to be observed that the *cartilaginous* stage, which is exceptional in the case of heterotopic bones and in the development of callus, is the rule (though not uniformly observed) in the reproduction of bones after resection.

The reproduction is more perfect when portions of the original cartilage or bone remain in the periosteal sheath, than when such portions are entirely taken away.

The intermediate cartilaginous structure which exists between the new diaphysis and the new epiphysis, fulfils temporarily the functions of the original cartilage of conjunction. It is owing to this, that reproduced bones grow in length, to a certain extent, though they never attain the length of the corresponding bones of the opposite side. As a rule also they remain more slender than normal, though there are exceptions, as in the cases where an exuberant reproduction takes place, and where the reproduced part has been from the beginning more voluminous than the portion removed.

Reproduced bone presents many more centres of ossification than bone in its normal development. This is owing to the unequal activity of different parts of the periosteum. The earliest ossification takes place in the course of the periosteal bloodvessels, and in general terms the activity of the periosteum is proportional to its vascularity.

The diversity of appearance of the reproduced and of the old bone gradually becomes obliterated, at least as far as naked eye observation is concerned; for the results of microscopic examination of the newly-formed substance, the author refers to his chapter on the structure of heterotopic bones.

The modifications brought about in surrounding structures by the reproduction of resected bones, are the same in kind, if different in degree, from those observed in fractures and other bone lesions. The changes in the soft parts gradually disappear, but those in the adjoining bones usually remain permanent. Thus, if the radius be the bone resected, and the limb be used before sufficient reproduction has been effected, the ulna will probably become the seat of osteophytic developments, or even of general circular hypertrophy. On the other hand, the resection of one bone renders the other peculiarly liable to fracture, or it may bend without breaking, and serious and persistent deformity ensue.

After resection of joints, the ligaments and all the fibrous tissues contribute to restore in a measure the form and usefulness of the part. They thicken and become vascular, their plastic elements undergo proliferation, while their intercellular substance becomes softened and otherwise modified. Vascular granulations proceed toward the centre of the articulation, and sometimes assume very much the consistence and general appearance of cartilage. New interarticular ligaments are developed, as are also fibrous disks, not unlike in appearance the loose cartilages occasionally met with in the articulations. When one articular cartilage has been preserved, a partial reproduction of the synovial sac may be noted; in other cases its functions are in a measure accomplished by the development of a kind of "bursa mucosa."

Chapter Eleventh treats of the general and local conditions of the regeneration of bone, and of artificial means for augmenting the reproduced osseous mass.

The perturbating circumstances which interfere with the success of experimental operations, are shown to be very much the same as those which affect the result in operations on the human subject. Neatness and care in the operative procedure, and careful and judicious after-treatment, are equally important in either case. Especially is it desirable that the parts involved in the operation should be afterwards kept at rest; as otherwise the new bone, even if sufficient in size, would in shape and direction be so irregular as materially to compromise the good which might, under other circumstances, have resulted from the operation.

The influence of *age* upon the success of subperiosteal resections is well marked. The very young and the old are alike unsuited for these operations. M. Ollier has succeeded best with rabbits of about three months, an age corresponding to from eight to fifteen years in the human subject. *Pregnancy* does not seem to produce any marked effect one way or the other. The *state of health* of the animal at the time of the experiment exercises, as might be expected, a decided influence upon the success or failure of the operation. *An intercurrent malady* may arrest the reparative process, or may even cause it to retrograde. *The febrile state* seems to have peculiarly the property of causing the absorption and disappearance of an ossification which has already begun. At one time M. Ollier lost thirty-five or forty rabbits in succession from an epizootic affection which prevailed simultaneously with the existence of erysipelas among his patients in the Hôtel-Dieu.

The *time* required for bony regeneration is very variable; in general terms, the sooner it begins the more perfect will it become.

With regard to the artificial means to be adopted to augment the amount of bony reproduction, we may refer our readers to what was said on the subject in considering the repair of fractures and the formation of callus. We may merely add, in this place, that the existence of a moderate amount of inflammation and suppuration is not only not injurious but even desirable; excessive suppuration, however, by destroying the osteogenetic layer of the periosteum will prevent the reproduction of bone.

In Chapter Twelfth we have a discussion of the growth of bones in general, and of the law of growth in the long bones. The experiments of Duhamel, Hunter, Flourens, and others, made by feeding animals with madder, are referred to, and their results stated to be confirmed by M. Ollier's personal observations. The soft tissues grow by interstitial formation; the bones merely by superposition. This is the rule, though experiments upon very young animals would seem to show that their bones have *temporarily* the power of interstitial growth as well.

The long bones grow (in length) by ossification of successive layers of their cartilages of conjunction. But they do not grow equally from either extremity. The humerus, tibia, and fibula grow chiefly from their upper ends; the femur, radius, and ulna from their lower extremities. Hence a law of the greatest importance, which M. Ollier formalizes as follows:—

> "In the upper limb, for the bones of the arm and forearm, it is the extremity which contributes to the elbow that grows the least.
>
> "In the lower limb, for the bones of the thigh and leg, it is the extremity which contributes to the knee that grows the most.
>
> "The two principal segments of the same limb are therefore found to be in an inverse relation towards each other; the bones of the upper extremity are also in an inverse relation with regard to the analogous bones of the lower extremity."

The importance of this law, which our author has experimentally established (as has likewise, independently, Professor G. M. Humphrey, of Cambridge), cannot be overestimated. It explains why resections of the knee are in young persons followed by such marked arrest of development, while resections of the hip and ankle do not entail the same disastrous results. Conversely, in the upper extremity, great shortening follows excisions of the shoulder and wrist-joints, while resection of the elbow has not the same disadvantage. Again, in *amputations* of the upper arm, as the principal source of growth remains, the bone (if the patient be a child) will inevitably grow more than the soft parts, and conicity, if not ulceration of the stump, result. This is not the case in the thigh, where by amputation the chief source of bony growth is removed. On the other hand, a conical stump is very apt to follow amputation of the leg, but will not occur after the same operation on the forearm.

A curious corollary to the above propositions is established by clinical observations; this is, that the extremity of election for normal growth is also the extremity of election for morbid growths, tumours, etc. Thus, exostoses, enchondromata, etc., affect in the upper extremity the shoulder and wrist rather than the elbow, while in the lower extremity their favourite seat is at the knee rather than at either the hip or ankle. The same law is stated by Broca to be observed with regard to the lesions of rachitis.

Chapter Thirteenth treats of the influence of irritation and ablation of different parts of a bone on its growth. The general causes of hypertrophy, or of arrest of development and atrophy of a bone, can be readily understood from what has gone before. It must be borne in mind that the periosteum differs from the cartilage of conjunction in that the former may be excited to additional activity by either direct or indirect irritation. The latter, on the contrary, responds in this way only to indirect irritation, while arrest of its function, and consequent bone shortening, result from any direct irritation of its structure. Prolonged want of use, or paralysis, give rise to atrophy of bones as of soft tissues. There is, however, a temporary elongation, due probably to the absence of pressure, to which M. Ollier gives the name of "*atrophic elongation.*" There is likewise, in cases of amputation, an elongation of the bones above the seat of the operation, and in cases of resection, an elongation of the bones both above and below. This is important, for it may sometimes serve to compensate in some degree for the arrest of development, which is uniformly observed in the bones immediately concerned in the operation. It is to be noted, however, that M. Ollier has not had occasion to observe this elongation in the human subject, though he has repeatedly noticed it in his experiments upon cats and other animals.

The peculiar reaction of the cartilage of conjunction, accordingly as it is irritated directly or indirectly, is well illustrated by the difference observed in cases of fracture of the shaft of a bone, and in cases of epiphyseal separation. In the former there is a positive elongation, which may compensate for a slight amount of overlapping; in the latter there is always arrest of development, no matter how soon or how perfectly the separation may have been reduced.

Chapter Fourteenth, the last of the first volume, treats of *osseous grafts.* M. Ollier has repeatedly obtained heterotopic bones by transplantation of periosteum; these bones are, however, not unfrequently after a time reabsorbed. But as it is a physiological law of universal applicability that the *stimulus of use* tends to the preservation and development of a part, it is possible that transplantation to supply a missing organ, such as the nose, would be more permanently successful than it is in experiments, which, however interesting and important, are of no physiological advantage to the animal concerned.

Hetero-periostic grafts, that is, from one animal to another of a different species, fail. M. Ollier has tried the experiment in sixty instances, and in only one obtained a success of very doubtful nature. In animals of the same species, however, the graft succeeds even after the animal from which the periosteum is derived has been dead twenty-five hours. The maintenance of a low temperature is essential for the success of the experiment, as above 16° C. (60°.8 Fahr.) putrefaction is very liable to ensue. M. Ollier has succeeded, with a temperature of —2° C. (+28°.4 Fahr.), but —10° C. (+14° Fahr.) is apparently too low. The maintenance of vitality of the transplanted periosteum is assisted by wrapping the part in a moist cloth. Brown-Séquard has found that the contractility of muscular tissue is restored thirteen hours after death by injection of arterial blood, and it is possible that the same means might be used to preserve the periosteal graft.

A heterotopic bone having been produced, its growth may be sometimes stimulated by moderate irritation. But the experiment is full of risk, and very apt to cause reabsorption rather than increased ossification.

Not only can heterotopic bones be developed by periosteal transplantation, but whole bones can be successfully grafted, as M. Ollier has experimentally proved in the case of rabbits, though he has failed with dogs. These grafted bones continue to grow in thickness, but do not increase in length. An exception is to be noted in the case of *white rats*, as shown by the experiments of Bert.

We have thus concluded our review of the first, or experimental portion of M. Ollier's great work. Our analysis has been necessarily very brief, and we have been compelled to pass very lightly, or even omit altogether, many points of great interest and practical value, which were, however, not absolutely essential to a comprehension of the object and scope of the main argument. We shall next proceed to a consideration of the clinical portion of M. Ollier's book, which occupies the second and larger volume of this most important contribution to surgery.

Fortunately (as our review has already extended to a considerable length), M. Ollier's second volume does not require, nor indeed would it admit of an analysis such as we have offered our readers of the first. The practice of subperiosteal surgery is, as yet, in its infancy; and our author's views are therefore confessedly, in a great many instances, theoretical, though perfectly reasonable, and probably hereafter to be confirmed by actual clinical observation.

M. Ollier writes for the future, as much, if not even more than for the present, and hence he has taken care by repeated observation and practice on the dead subject, to ascertain the best and most suitable procedure in the case of every subperiosteal operation which he has proposed. His book may thus be regarded as not only an admirable exposition of the present state of science as regards the subject of his labours, but as also an elaborate and satisfactory manual of operative subperiosteal surgery. Nor has our author limited himself to the bounds of his own special field of investigation; his work contains several distinct chapters, besides innumerable incidental remarks, upon the subject of bone-surgery in general.

Chapter First treats of necrosis in man, and of the regeneration of necrosed parts. The various forms of necrosis, and the antiquity of the fundamental principles of their treatment, are considered, with the process by which osseous regeneration is in such cases accomplished. The right time for surgical interference, and the means which may be employed to hasten the separation of sequestra are referred to, and we are pleased to observe that our author adheres, except in particular cases, to the time-honoured and most judicious rule, not to interfere until nature has done all that she is capable of accomplishing. Among the exceptions alluded to, are cases of necrosis of the upper and lower maxillæ, in which a positive injury is inflicted upon the patient by the presence of a constant source of infection and of systemic poisoning in the mouth, and in these cases the surgeon is therefore not only authorized to interfere before the separation of the sequestrum, but is positively reprehensible for neglecting to do so. With regard to the various plans proposed for hastening the loosening of sequestra, our author states that he has found all unsatisfactory, and some not free from danger.

Chapter Second considers the "abrasion, hollowing out (*évidement*), and cauterization of bones, or losses of substance which do not involve the length of the bone, and the method of bony reparation in such cases." The indications for each of these several modes of treatment are clearly pointed out, and their limits of applicability plainly defined. Our readers are doubtless aware, that the eminent Strasbourg surgeon, M. Sédillot, has lately given a fresh impetus to the practice of the process of hollowing-out diseased or dead portions of bone, and has given the operation the name of "*évidement*," by which it is here indicated. His learned and excellent treatise "*De l'évidement des os*," receives proper and respectful attention at the hands of M. Ollier, but the latter has, we think, conclusively shown that the process of *évidement* is only applicable to a limited number of cases, and not at all to those in which subperiosteal resection is especially indicated. Still the method of M. Sédillot is of great value, and our author has himself employed it with most gratifying results in several instances. It is especially useful as a supplementary operation after resection, as by this means the entire removal of the diseased structure can often be accomplished, without the sacrifice of such a large portion of the entire thickness of the bone as would otherwise be required.

In Chapter Third, the regeneration of bones by their periosteal sheaths is again brought under consideration; and cases adduced which prove the fact, in one, by demonstration on the living subject of the form of the new bone and the re-establishment of the limb's functions, and, in another instance, by the result of post-mortem examination, the patient having lived three years subsequently to the time of the operation.

The first case referred to is that of a young girl of fifteen, from whom M. Ollier removed by the subperiosteal process the upper half of the left humerus; the bone, in spite of several untoward occurrences, was completely regenerated (except, of course, the articular head) in less than a year; and the patient was able at the end of that time to return to her usual employment, a living monument not only of M. Ollier's surgical skill, but, what is more important, of the truth and practical applicability of his doctrines on the subject of subperiosteal surgery.

The other case is that of a young man upon whom our author performed excision of the whole thickness of the sternum, with resection of the costal cartilages; the patient dying of tuberculosis three years afterwards, an autopsy showed bony reproduction of the sternum, and ossification, more or less complete, of the fourth, sixth, and seventh costal cartilages on both sides, and of the third upon the left side.

Several cases are quoted from the writings of the older surgeons, such as White, Vigarous, Delamotte, and others, in which bony reproduction was observed; cases which at the time were considered merely as surgical curiosities, but which are now seen to have been the natural results of the normal physiological action of the periosteum. One fact which it is important to bear in mind in examining the results of cases reported by the older surgeons, is that while in some cases the separation of the periosteum is only to be accomplished by a tedious and painstaking process, in others it is almost impossible to avoid its preservation, the periosteum in such cases adhering more closely to the soft tissues than to the bones. Such is the state of affairs with the healthy bones of children, as well as in cases of inflammation, etc., in the adult.

Chapter Fourth takes up the subject of subperiosteal resections in general, giving rules for the operative procedure, and studying the conditions of osseous regeneration. We cannot pretend to follow our author into the minute directions which he lays down for the guidance of the surgeon in the case of each particular operation, but may say, in general terms, that the incisions should, as a rule, be single, in the direction of the axis of the limb, and as much as possible involving the intermuscular spaces rather than the muscles themselves. If it be necessary in any case to divide a muscle, it should be done in such a way as not to compromise its principal nerve. The periosteum is never to be detached with the cutting edge of a knife, but with the handle, or better still a kind of rasp, which the author describes and figures under the name of "*sonde-rugine.*" Care should be taken to preserve the deep (osteogenetic) layer of the periosteum by pressing firmly against the bone in the process of separation. This part of the operation may generally be facilitated by previously dividing the bone with a chain-saw or otherwise at the middle of the portion to be removed. Great care must, of course, be exercised not to separate the periosteum from the surrounding soft tissues.

It is generally recommended, after a resection, to clip off with scissors all the fungous excrescences which are found on the surrounding fibrous structures; M. Ollier finds it better to allow them to remain, but he recommends that they should be freely touched with the actual or potential cautery (nitrate of silver). In these cases the wound must be kept open, and should be dressed with stimulating applications: in traumatic cases, however, the dressing should be of the simplest and most emollient character. The limb must, of course, be kept at rest after the operation, with appropriate means of extension and support, to prevent undue shortening or other deformity.

After an ordinary resection, the rule is to place the resected parts in contact; in the subperiosteal operation this rule must be modified in view of the anticipated osseous reproduction. In a young subject, and especially in the upper extremity, the parts may be kept fully extended; but where there is reason to fear imperfect regeneration, and generally in the lower extremity (where more than in the upper it is necessary to avoid the risk of a false joint) it will be found better to approximate the resected extremities or even sometimes to place them in absolute contact.

Subperiosteal, as compared with ordinary resection, is a more difficult and much more tedious operation. This is however a matter of but slight importance since the general introduction of anæsthetics. Its results are more satisfactory, and there is reason to believe, though it cannot as yet be positively asserted, that it is an operation which is attended with less risk to life than is that of resection when the periosteum is not preserved.

Chapter Fifth treats of the general indications for subperiosteal resection, in hospital practice, civil (domestic) practice, and military practice respectively. The author remarks, and we think very justly, that it is a pity that hospital practice (as it nearly always does) should establish the rule for military (field) surgery, rather than country practice, to which the work of the army surgeon very often more nearly approximates. Thus certain operations, as for instance excisions of the knee-joint, are almost universally fatal in hospital practice, while in the healthy surroundings of country life they do very well. This particular operation is not of course generally suitable in military practice on account of the question of transportation; but with regard to other excisions and resections, and especially those of the upper extremity, our author thinks, and we quite agree with him, that a new field is opened to conservative military surgery by the subperiosteal mode of operation. Many cases, of course (shocking as it may appear), must and will still be amputated *to save time;* for, after an action, *time* is an element that demands the gravest consideration of the medical officer; but there are many other cases which do not require immediate attention, and it is for these especially that subperiosteal resections are particularly adapted. It is indeed in secondary operations that the best results may often be expected from the subperiosteal method, for in such cases the inflammatory action will have not only loosened and thickened the periosteum, but will have already prepared it for the most perfect exercise of its osteogenetic and reproductive powers.

In civil or hospital practice the cases of traumatic origin in which the question of resection is involved, are compound dislocations, and compound fractures where a fragment projects through the skin.

In the former, we entirely agree with M. Ollier, that primary subperiosteal resection should be invariably practised. In the latter, our author advises that where the fragment is bared of periosteum, and even if not, in the case of a child, the projecting portion should be resected previously to attempting reduction; we confess that we have rarely seen any advantage from this mode of proceeding in the cases in question, and should usually prefer, where amputation was not indicated, to trust the case to nature, reducing the fracture as completely as possible, by the aid of free incisions of the soft parts if necessary.

In cases of compound fracture involving the larger articulations, M. Ollier likewise recommends subperiosteal resection. He has done the operation himself in one case of compound fracture of the elbow-joint, but the patient unfortunately died of pyæmia, so that the result, as regards bony reproduction, could not be determined. We confess that, with our present light, we should prefer, unless the fracture was very limited in extent, to resort to amputation, believing that by so doing we were affording our patient the best chance for preservation of life.

Cases of acute osteitis, of acute subperiosteal abscess, and even of acute osteomyelitis, when confined to the diaphysis of a bone, can often be successfully treated by the lesser operations of scraping, cauterization or *évidement*, and even sometimes without any operation at all; when, however, the disease attacks an epiphysis, and the neighboring joint becomes involved, the case is more serious, and resection, or if more than one joint be involved, amputation must often eventually be resorted to. But even in these cases, the operation should not be employed until all ordinary modes of treatment have failed; for, thanks to the labours of Bonnet and others, the prognosis of suppurative arthritis is not now considered so uniformly unfavourable as it was formerly.

In neoplastic formations of bone, whether malignant or otherwise, subperiosteal resection should be avoided; here the preservation of the periosteum is at best of but doubtful utility, and must often prove positively injurious by reproducing the disease; hence in these cases the rule must still be, as formerly, total excision or amputation, according to the nature of the bone affected.

There is another class of cases where subperiosteal resection may sometimes be usefully employed, viz., where, the operation is required as a preliminary to the removal of deep-seated tumours, as for instance in the maxillary sinus.

Chapter Sixth treats of the subperiosteal resection and ablation of the bones of the head. Sundry interesting cases are given in which the upper and lower jaws or portions of them have been severally removed, but no reference is made to the very important case communicated by Dr. William Hunt, of this city, to the Philadelphia College of Physicians, and published in the number of this Journal for April, 1865 (p. 353), and January, 1866 (p. 163). This case, as well as that of Dr. Charles S. Boker (see *Am. Journ. Med. Sci.* for April, 1865, p. 555), either operation being for phosphorus disease, seems to us to prove both the possibility and the propriety of removal of the lower jaw being effected *without external incision.*

M. Ollier seems not to have been acquainted with either of these cases, for he bases his objection to the operation without cutaneous wound upon the *extreme difficulty* of the procedure, stating, indeed, that the operation is practicable upon the cadaver, but should not be attempted upon the living subject. Not only do Dr. Hunt's and Dr. Boker's cases show that the operation is far more easy than supposed by M. Ollier, but we may add that the bony regeneration in Dr Hunt's patient was more complete than it seems to have been in most if not all of the cases which our author details in the chapter under consideration.

We do not propose to follow M. Ollier in his remarks upon subperiosteal resection as applied to each separate portion of the human frame; suffice it to say that he has practised this method with greater or less success upon the clavicle, scapula, ribs, pelvic bones, humerus, ulna, tibia, fibula, and bones of the hand and foot. Minute and careful directions are given for the operative procedure as applied to each bone, and illustrative cases from his own practice and that of others fully detailed, the results conscientiously stated, and justly and reasonably appreciated.

The same plan is adopted, in Chapters Tenth to Twelfth, for the subperiosteal resections of the joints. Our author has operated in this way upon the shoulder, elbow, and ankle-joints, and generally with very gratifying results. Excision of the hip he has not performed at all, and in resections of the knee he has not attempted to obtain bony regeneration, preferring to place the cut surfaces of the femur and tibia in contact, and even to unite them by suture, with a view to obtaining bony anchylosis.

In his thirteenth chapter, M. Ollier treats of "some accidents in cases of fracture, due to exuberant or defective callus." Under the first heading is narrated an extremely interesting case, with which (as it has been extensively quoted by other journals from the *Gazette Hebdomadaire*, in which it first appeared) many of our readers are doubtless already acquainted. In this case the radial nerve was, after a fracture of the humerus, compressed between a projecting point of bone, and a canal which was formed around it by an excess of callus; great pain, and afterwards complete paralysis resulting from the accident. M. Ollier, six months after the occurrence of the injury, cut down upon the part, and with a chisel and mallet formed a wide groove in the callus, and removing the offending point of bone, brought the wound together; thus leaving the nerve completely protected by a bony wall, which at the same time did not compress it in any part. The wound soon healed, and in a year the nerve had completely regained its normal power, the patient being able to use his hand in every way, though it was still slightly weaker than its fellow.

With regard to the operation of subperiosteal resection in cases of ununited fracture, M. Ollier insists upon the importance of suturing the resected portions of bone themselves, but attributes no advantage to the suture of the periosteum. Our readers will observe that this is precisely the plan which has been so successfully adopted in this country by Dr. Henry J. Bigelow, of Boston. [See No. of this Journal for Oct. 1867, p. 507.]

Chapter Fourteenth treats of periosteal and bony grafts in the human subject. Our author upon one occasion transplanted a strip of periosteum obtained from the tibia to the forehead, as a preliminary to the operation of rhinoplasty; the result was, however, not sufficiently encouraging to tempt him to repeat the proceeding. The graft had apparently become entirely gangrenous, and it was only in tearing it away with forceps, that the screams of the patient, and a few drops of blood, showed that it had actually contracted adhesions at some points.

An account is quoted from Percy, of two attempts made by that distinguished surgeon to supply a loss of substance in gunshot fractures of the tibia, by the introduction of pieces of *beef bone:* the attempt, it is needless to say, resulting in complete failure.

A good, but somewhat apocryphal story is also quoted from Job à Meckrem, of a soldier, who losing by a sabre wound a considerable portion of his skull, had the deficiency supplied from the head of a dog, which was immolated for the occasion. The cure (so the story goes) was perfect, but the matter unfortunately coming to the ears of the patient's father confessor, absolution was withheld until the surgeon's dirty work had been undone, the foul fragment cast out again, and the patient eventually submitted to a more Christian mode of treatment.

Chapter Fifteenth treats of osteoplasty in general, and of its two varieties, the direct or osseous, and the indirect or periosteal. The principal applications of these proceedings are in cases of rhinoplastic and uranoplastic operations. Langenbeck, after an operation of periosteal rhinoplasty, demonstrated the formation of new bone by exsecting a piece and placing it in the field of a microscope. M. Ollier has not made the direct examination, and has only been able in one of five cases to satisfy himself that a true bone formation had taken place. The details of this case are given, and the appearances before and after the operation represented by a plate. In Dr. Bigelow's case, it will be remembered, the result was completely unsuccessful.

Chapter Sixteenth and last treats of "preliminary osteotomy," a new operation for naso-pharyngean polypus, and of amputations with a periosteal flap. The new operation seems to be exceedingly ingenious, and, judging from the reported cases in which it has been practised, very successful; but as it is not very often required, we do not think it worth while to occupy our limited space with its description, preferring to refer those of our readers who may be interested in the matter to M. Ollier's volume itself.

With regard to the preservation of a periosteal flap in amputations, though our author first suggested the practice, he is now by no means convinced of its utility. An exception is however to be made in the case of the tibia, where, by the adoption of this plan, M. Ollier thinks the surgeon can avoid the perforation of the anterior flap by the tibial spine, which is so often observed after the operation as ordinarily performed.

Two appendices conclude the volume, one giving the details of three observations (by Coutavoz, Vigarous, and White respectively), which were only alluded to in the main part of the work, and the other furnishing later reports of the condition of several patients whose cases were not terminated when the book was placed in the printer's hands.

We have thus completed our review of this magnificent result of M. Ollier's labours, and, in taking leave of the work, cannot but express the opinion, that not only the profession but mankind at large owe him no inconsiderable debt of gratitude for his most valuable contributions to the science and art of surgery. There are some slight inaccuracies in his book, which will doubtless be corrected in a subsequent edition; thus, on page 207 (Vol. II.) we are told in the third, sixth, and ninth lines respectively, that the same patient was fifty-seven, fifty-four, and fifty-one years old. If we were to indicate a fault, it would be that the work is rather too much spun out; there are a good many repetitions, and a good many matters which though sufficiently interesting in themselves, do not strike us as particularly pertinent to the subject under discussion. We fear that the length of the volumes will stand in the way of their general circulation, at least in countries other than the author's own; for not only is the cost of so elaborate a work a matter of consideration with most doctors, but the perusal of a thousand large pages in a foreign language, is a task which by many will be approached with misgiving, if not altogether declined.

M. Ollier's style we have found perspicuous, and, usually, sufficiently elegant: he has, however, as we have already indicated, not learned that in which Pope tells us even Dryden was deficient—

> *"The greatest art of all—the art to blot."*

Although not free from misprints, these volumes, both as to press-work and paper, reflect great credit upon MM. Masson, the publishers; and the nine plates and forty-five wood-cuts, while characterized by the usual French artistic elegance, are also remarkable for being executed with perhaps even more than the usual French accuracy. J. A., Jr.